

1    WHAT IS CLAIMED IS:

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- 3    1.    A method for separating mono-olefins comprising:
- 4            a) contacting a mixture comprising di-olefins and mono-olefins with an
- 5            olefin-complexing metal salt dissolved, dispersed, or suspended in
- 6            an ionic liquid;
- 7            b) maintaining such mixture in contact with such olefin-complexing
- 8            metal salt for sufficient time to selectively complex the di-olefins
- 9            over the mono-olefins to form a metal salt/olefin complex; and
- 10          c) separating the non-complexed mono-olefins.

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- 12    2.    The method of claim 1, further comprising desorbing the di-olefins from
- 13          the metal salt/olefin complex.

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- 15    3.    The method of claim 2, wherein said ionic liquid is capable of forming a
- 16          solution, suspension or dispersion with said olefin-complexing metal
- 17          salt.

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- 19    4.    The method of claim 3, wherein the amount of said olefin-complexing
- 20          metal salt is adjusted so as to complex essentially only the di-olefins.

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- 22    5.    The method of claim 1, wherein the metal salt comprises a Group IB
- 23          metal.

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- 25    6.    The method of claim 5, wherein the metal salt is a copper salt.

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- 27    7.    The method of claim 6, wherein the metal salt is CuOTf.

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- 29    8.    The method of claim 5, wherein the metal salt is a silver salt.

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- 31    9.    The method of claim 8, wherein the metal salt is AgBF<sub>4</sub>.

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- 33    10.   The method of claim 1, wherein the mono-olefin and di-olefin-

- 1 containing mixture is a gaseous olefin-containing stream.
- 2
- 3 11. The method of claim 1, wherein said mixture is contacted with said
- 4 olefin-complexing metal salt in a distillation apparatus.
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- 6 12. The method of claim 11, further comprising separating said non-
- 7 complexed mono-olefins by distillation in said distillation apparatus.
- 8
- 9 13. The method of claim 12, further comprising desorbing said di-olefins
- 10 from said metal salt/olefin complex by distillation in said distillation
- 11 apparatus.
- 12
- 13 14. The method of claim 1, wherein said mixture is contacted with said
- 14 olefin-complexing metal salt in a system of one or more liquid mixers.
- 15
- 16 15. The method of claim 14, further comprising separating said non-
- 17 complexed mono-olefins from said metal salt/olefin complex by
- 18 decantation.
- 19
- 20 16. The method of claim 15, further comprising desorbing said di-olefins
- 21 from said metal salt/olefin complex in a regeneration apparatus.
- 22
- 23 17. The method of claim 16, further comprising sending the bottoms from
- 24 said regeneration apparatus to said system of liquid mixers.
- 25
- 26 18. The method of claim 1, wherein the mixture of mono- and di-olefins is
- 27 derived from wax hydrocracking, paraffin dehydrogenation, or
- 28 combinations thereof.
- 29
- 30 19. The method of claim 1, further comprising subjecting the mixture to
- 31 partial hydrogenation prior to the contacting step.
- 32
- 33 20. A method for separating mono-olefins comprising:

- 1 a) contacting a mixture comprising di-olefins and mono-olefins with an
- 2 olefin-complexing metal salt dissolved, dispersed, or suspended in
- 3 an ionic liquid;
- 4 b) maintaining such mixture in contact with such olefin-complexing
- 5 metal salt for sufficient time to complex the mono-olefins and di-
- 6 olefins with the olefin-complexing metal salt to form a metal
- 7 salt/olefin complex; and
- 8 c) selectively desorbing the mono-olefins from the metal salt/olefin
- 9 complex.
- 10
- 11 21. The method of claim 20, further comprising desorbing the di-olefins
- 12 from the metal salt/olefin complex.
- 13
- 14 22. A method for separating mono-olefins and/or di-olefins comprising:
- 15 a) contacting a mixture comprising di-olefins, mono-olefins and non-
- 16 olefins with an olefin-complexing metal salt dissolved, dispersed or
- 17 suspended in an ionic liquid;
- 18 b) maintaining such mixture in contact with such olefin-complexing
- 19 metal salt for sufficient time to complex the mono-olefins and di-
- 20 olefins with the olefin-complexing metal salt to form a metal
- 21 salt/olefin complex;
- 22 c) separating the non-complexed non-olefins; and
- 23 d) selectively desorbing the mono-olefins from the metal salt/olefin
- 24 complex.
- 25
- 26 23. The method of claim 22, further comprising desorbing the di-olefins
- 27 from the metal salt/olefin complex.
- 28
- 29 24. The method of claim 23, wherein said ionic liquid is capable of forming
- 30 a solution, suspension or dispersion with said olefin-complexing metal
- 31 salt.
- 32
- 33 25. The method of claim 22, wherein the metal salt comprises a Group IB

- 1 metal.
- 2
- 3 26. The method of claim 25, wherein the metal salt is a copper salt.
- 4
- 5 27. The method of claim 26, wherein the metal salt is CuOTf.
- 6
- 7 28. The method of claim 25, wherein the metal salt is a silver salt.
- 8
- 9 29. The method of claim 28, wherein the metal salt is AgBF<sub>4</sub>.
- 10
- 11 30. The method of claim 22, wherein the non-olefins comprise at least one
- 12 of paraffins, oxygenates, aromatics, or mixtures and combinations
- 13 thereof.
- 14
- 15 31. The method of claim 30, wherein the paraffins comprise cycloparaffins.
- 16
- 17 32. The method of claim 22, wherein the mono-olefins comprise at least
- 18 one of ethylene, propylene, or mixtures and combinations thereof.
- 19
- 20 33. The method of claim 32, wherein the ethylene is produced in an
- 21 ethylene cracker, an EP cracker, a naphtha cracker, or combinations
- 22 thereof.
- 23
- 24 34. The method of claim 22, wherein the olefins are produced in an
- 25 apparatus selected from the group consisting of an FCC unit, naphtha
- 26 hydrotreater, catalytic reformer, distillate hydrotreater, hydrocracker,
- 27 coker, RFCC unit, RDS unit and combinations thereof.
- 28
- 29 35. The method of claim 22, wherein the olefins are derived from paraffin
- 30 dehydrogenation, ethylene oligomerization, wax hydrocracking, or
- 31 combinations thereof.
- 32
- 33 36. The method of claim 22, wherein the olefins are produced in a Fischer-

- 1 Tropsch synthesis.
- 2
- 3 37. The method of claim 22, wherein the mono-olefins are normal alpha
- 4 olefins derived from the ethenolysis of heavier internal olefins.
- 5
- 6 38. The method of claim 22, wherein the olefins are separated from a
- 7 recycle stream in a Fischer-Tropsch synthesis to reduce the amount of
- 8 olefins recycled from a Fischer-Tropsch unit to an upstream methane
- 9 reformer.
- 10
- 11 39. The method of claim 22, wherein the olefin-containing mixture is a
- 12 gaseous olefin-containing stream.
- 13
- 14 40. The method of claim 22, wherein said mixture is contacted with said
- 15 olefin-complexing metal salt in a distillation apparatus.
- 16
- 17 41. The method of claim 40, further comprising separating said non-
- 18 complexed non-olefins from said metal salt/olefin complex by
- 19 distillation.
- 20
- 21 42. The method of claim 41, further comprising desorbing said mono-
- 22 olefins from said metal salt/olefin complex by distillation in said
- 23 distillation apparatus.
- 24
- 25 43. The method of claim 42, further comprising desorbing said di-olefins
- 26 from said metal salt/olefin complex by distillation in said distillation
- 27 apparatus.
- 28
- 29 44. The method of claim 22, wherein said mixture is contacted with said
- 30 olefin-complexing metal salt in a system of one or more liquid mixers.
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- 32 45. The method of claim 44, further comprising separating said non-
- 33 complexed non-olefins from said metal salt/olefin complex by



- 1 from the second metal salt/olefin complex.
- 2
- 3 52. The method of claim 51, wherein the amount of said olefin-complexing
- 4 metal salt is adjusted so as to complex essentially only the di-olefins.
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- 6 53. The method of claim 1, wherein said ionic liquid is comprised of anions
- 7 and cations, wherein;
- 8 said anions are selected from the group consisting of halide salts,
- 9 metal anions, chloroaluminate, bromoaluminate, gallium chloride,
- 10 tetrafluoroborate, tetrachloroborate, hexafluorophosphate, nitrate,
- 11 trifluoromethane sulfonate, methylsulfonate, *p*-toluenesulfonate,
- 12 hexafluoroantimonate, hexafluoroarsenate, tetrachloroaluminate,
- 13 tetrabromoaluminate, perchlorate, hydroxide anion, copper dichloride
- 14 anion, iron trichloride anion, antimony hexafluoride, copper dichloride
- 15 anion, zinc trichloride anion, lanthanum anion, potassium anion, lithium
- 16 anion, nickel anion, cobalt anion, manganese anion, and combinations
- 17 and mixtures thereof; and
- 18 said cations are selected from the group consisting of cyclic and non-
- 19 cyclic quaternary ammonium cations, alkylammoniums, pyridiniums,
- 20 substituted pyridiniums, N-alkylpyridiniums, imidazoliums, substituted
- 21 imidazoliums, N,N'-dialkylimidazoliums, pyrroliniums, substituted
- 22 pyrroliniums, phosphoniums, alkylphosphoniums, arylphosphoniums,
- 23 1-butyl-3-methylimidazolium, N-hexylpyridinium, 1-hexyl-3-
- 24 methylimidazolium, (C<sub>8</sub>H<sub>17</sub>)<sub>3</sub>MeN, Bu<sub>2</sub>Me<sub>2</sub>N, and mixtures and
- 25 combinations thereof.
- 26
- 27 54. The method of claim 22, wherein said ionic liquid is comprised of
- 28 anions and cations, wherein;
- 29 said anions are selected from the group consisting of halide salts,
- 30 metal anions, chloroaluminate, bromoaluminate, gallium chloride,
- 31 tetrafluoroborate, tetrachloroborate, hexafluorophosphate, nitrate,
- 32 trifluoromethane sulfonate, methylsulfonate, *p*-toluenesulfonate,
- 33 hexafluoroantimonate, hexafluoroarsenate, tetrachloroaluminate,

- 1 tetrabromoaluminate, perchlorate, hydroxide anion, copper dichloride
- 2 anion, iron trichloride anion, antimony hexafluoride, copper dichloride
- 3 anion, zinc trichloride anion, lanthanum anion, potassium anion, lithium
- 4 anion, nickel anion, cobalt anion, manganese anion, and combinations
- 5 and mixtures thereof; and
- 6 said cations are selected from the group consisting of cyclic and non-
- 7 cyclic quaternary ammonium cations, alkylammoniums, pyridiniums,
- 8 substituted pyridiniums, N-alkylpyridiniums, imidazoliums, substituted
- 9 imidazoliums, N,N'-dialkylimidazoliums, pyrroliniums, substituted
- 10 pyrroliniums, phosphoniums, alkylphosphoniums, arylphosphoniums,
- 11 1-butyl-3-methylimidazolium, N-hexylpyridinium, 1-hexyl-3-
- 12 methylimidazolium, (C<sub>8</sub>H<sub>17</sub>)<sub>3</sub>MeN, Bu<sub>2</sub>Me<sub>2</sub>N, and mixtures and
- 13 combinations thereof.
- 14
- 15 55. A method for optimizing the method of claim 1, comprising preparing a
- 16 combinatorial library including a plurality of combinations of ionic
- 17 liquids and olefin-complexing metal salts, and evaluating the library for
- 18 its ability to separate di-olefins from a mixture comprising mono-olefins
- 19 and di-olefins.
- 20
- 21 56. A method for optimizing the method of claim 22, comprising preparing
- 22 a combinatorial library including a plurality of combinations of ionic
- 23 liquids and olefin-complexing metal salts, and evaluating the library for
- 24 its ability to separate olefins from a mixture comprising olefins and
- 25 non-olefins.